RAMBOLL ENVIRON

2015 North American Site Solutions Technology Transfer Conference Abstract

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Background/Objectives: For many years, the risk assessment/risk management practice area group in Princeton has recognized that the Johnson and Ettinger model (JEM) can grossly overestimate the indoor air concentration resulting from vapor intrusion from VOCs in soil. Such overestimation can occur because the model assumes that the soil concentration of a VOC remains constant, even though it also assumes that the VOC volatilizes from the soil and enters the overlying building over time. This allows the JEM to violate the law of mass conservation and to predict an indoor air concentration that implies a VOC mass in the soil under the building that is far greater (often an order of magnitude more) than the actual mass present in the subsurface soil.

Approach/Activities: In this presentation, we will discuss an approach that we developed to ensure estimated indoor air concentrations, due to vapor intrusion from soil, do not violate the law of mass conservation. The basic idea in the approach is that the long-term average indoor air concentration has an upper-bound that equals the VOC mass in the soil divided by the air volume assumed to flow through the indoor space. We will discuss considerations in applying the approach by using project examples. The discussion will include: adaptation to available soil characterization data; mass computation techniques; agency perceptions; and relation to EPA's June 2015 and PADEP's (draft) July 2015 vapor intrusion guidance (e.g., use of soil vs. soil gas data).

Results/Lessons Learned: Our many projects over the past 10 years have demonstrated the importance of checking for violations of the law of mass conservation in vapor intrusion assessments for soil. Using the approach discussed, we have been able to avoid concluding that soil concentrations have a significant potential to pose an unacceptable risk via vapor intrusion exposure when that potential may actually be quite low.

USING A VOC'S TOTAL MASS IN VADOSE ZONE SOIL TO ASSESS VAPOR INTRUSION

Presented by:
Renee Sandvig, Manager | Princeton, NJ

Site Solutions Technology Transfer Conference
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TRADITIONAL METHOD: NOTHING EVER CHANGES

Objective: do not exceed long-term average IA risk-based limit over the exposure period

Assumptions:

- IA concentration is constant
- Ventilation rate is constant
- Soil gas entry rate is constant
- Subsurface source is constant
- Therefore, is constant

IA = SG x α

$$JEM\ \alpha = \frac{\left[\frac{D_T^{eff} A_B}{Q_{building} L_T}\right] \exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right)}{\exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right) + \left[\frac{D_T^{eff} A_B}{Q_{building} L_T}\right] + \left[\frac{D_T^{eff} A_B}{Q_{soil} L_T}\right]\left[\exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right) - 1\right]}$$

EPA Generic Subslab = 0.03

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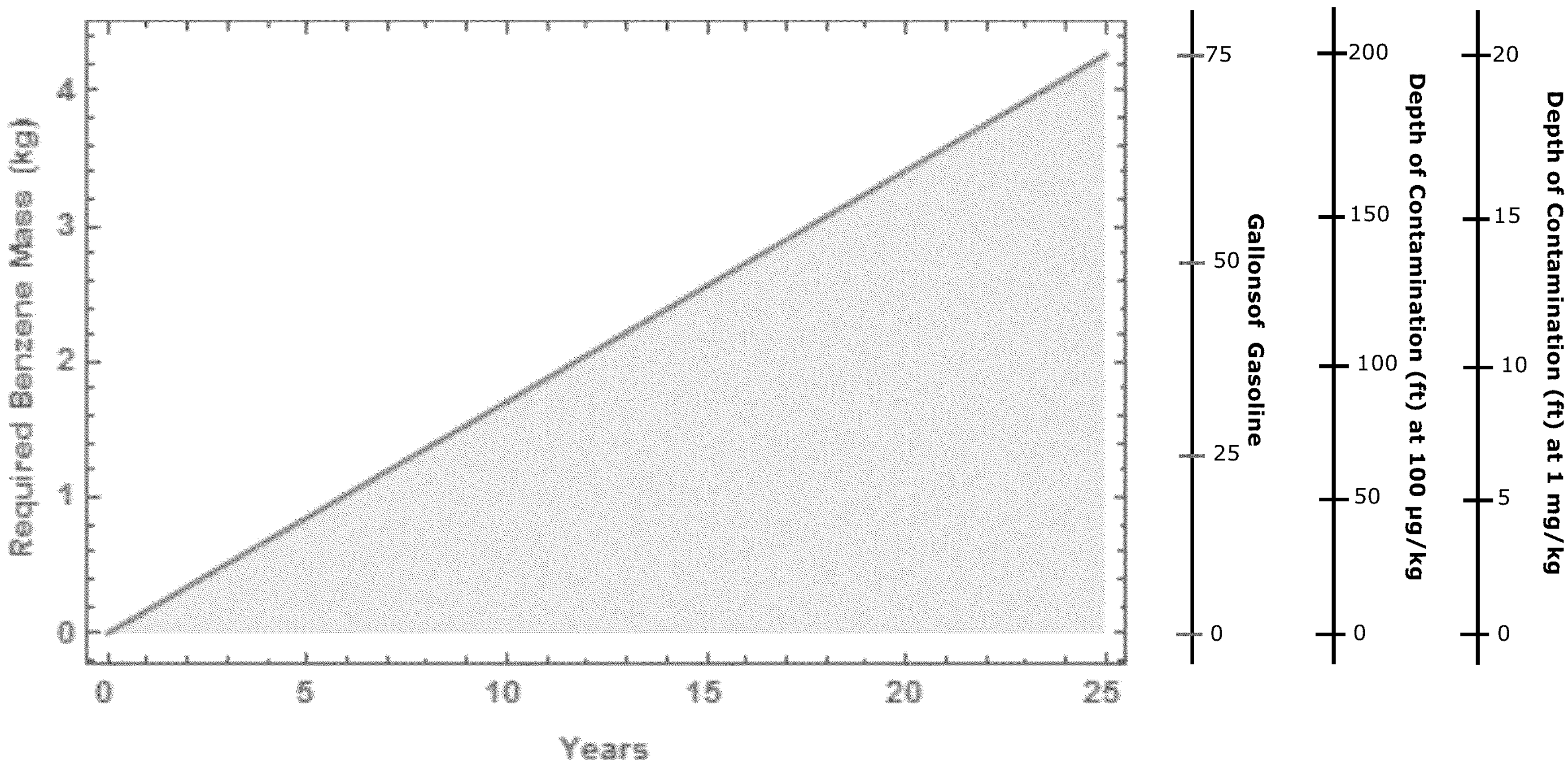
BUT WILL THERE BE ENOUGH MASS TO FEED THAT HUNGRY BUILDING?



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WHAT IF ... THE ENTIRE MASS (BUT NO MORE) ENTERS THE BUILDING?

IA = SG x α

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$$M = C_{soil} \times \rho_b \times V_{soil}$$

$$V_{b,ED} = Ach \times V_{occ} \times ED$$

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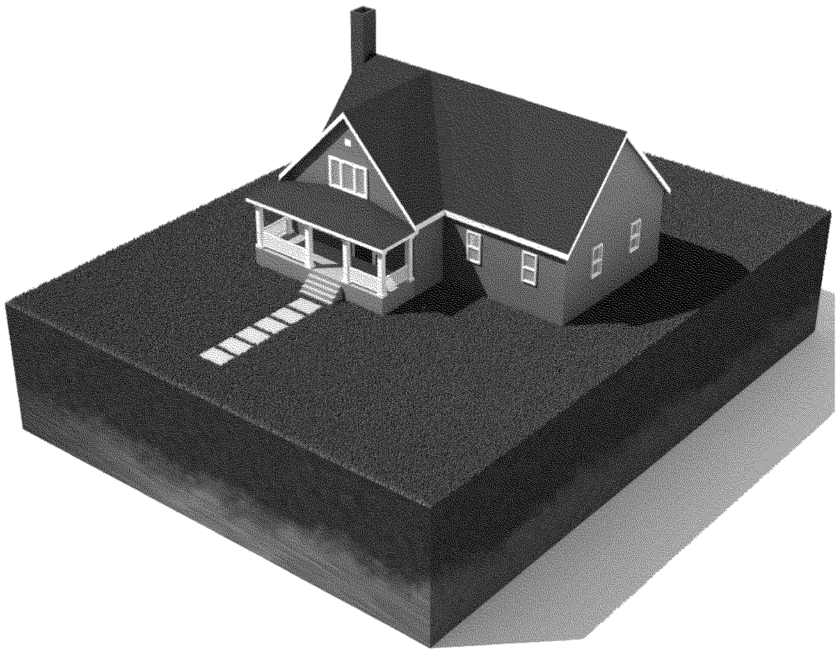
HOW MUCH SITE CHARACTERIZATION DO WE NEED?



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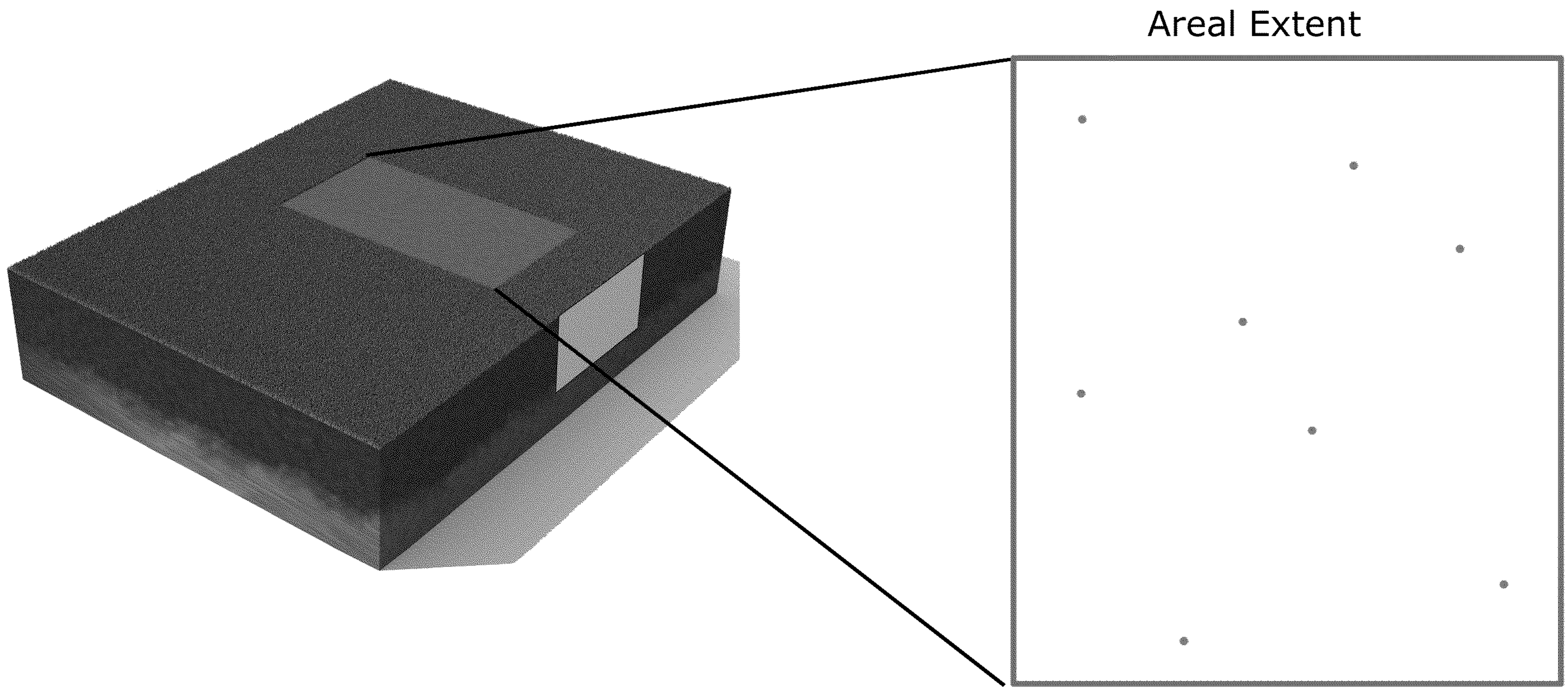

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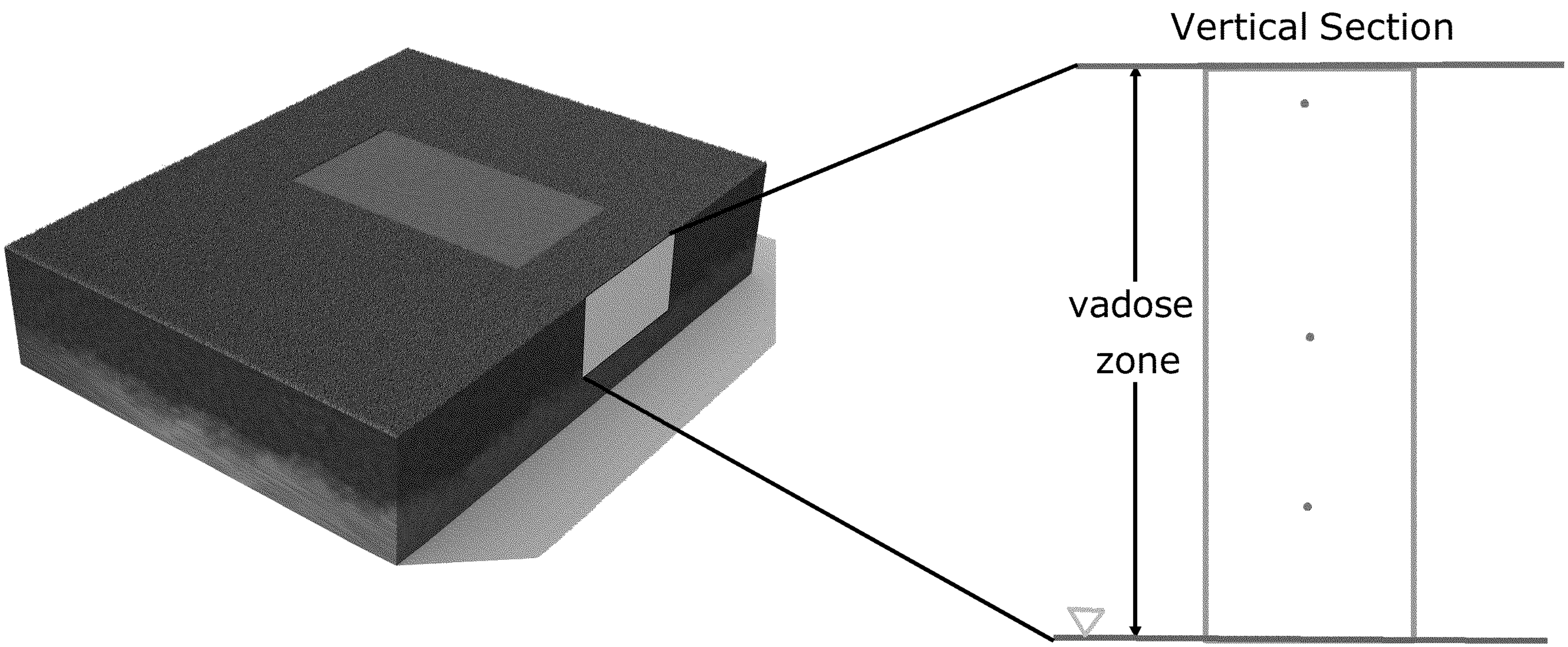

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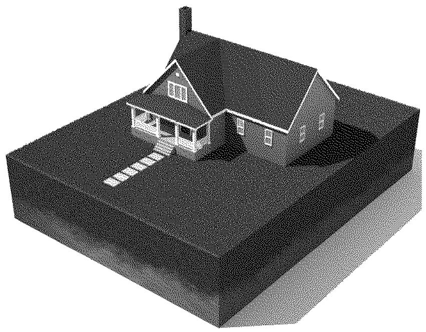

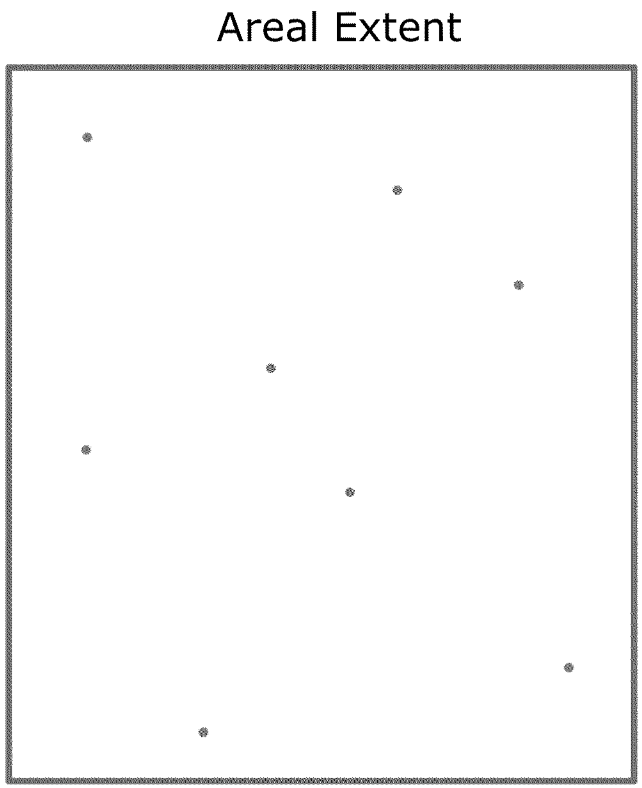

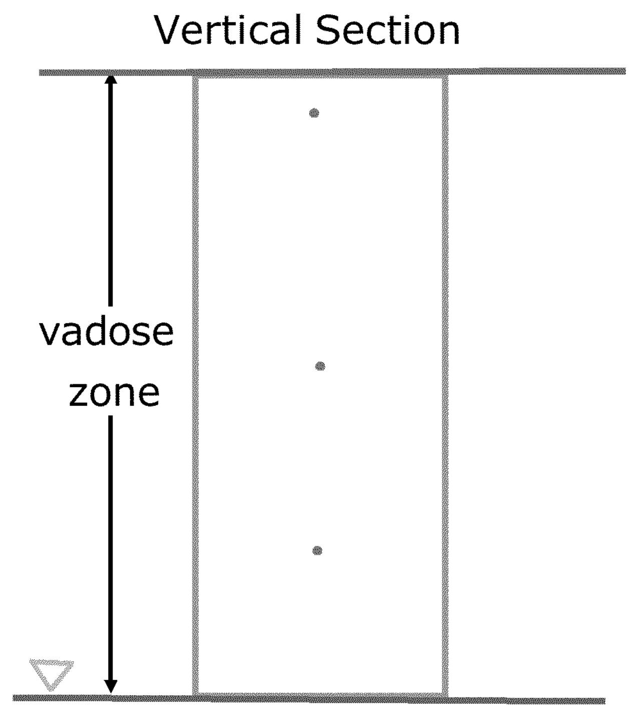

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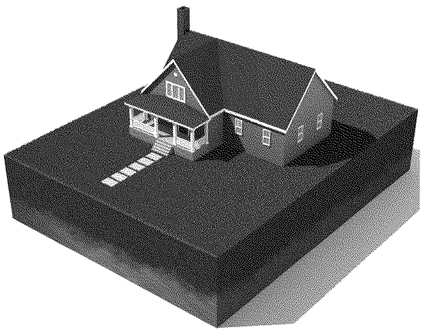
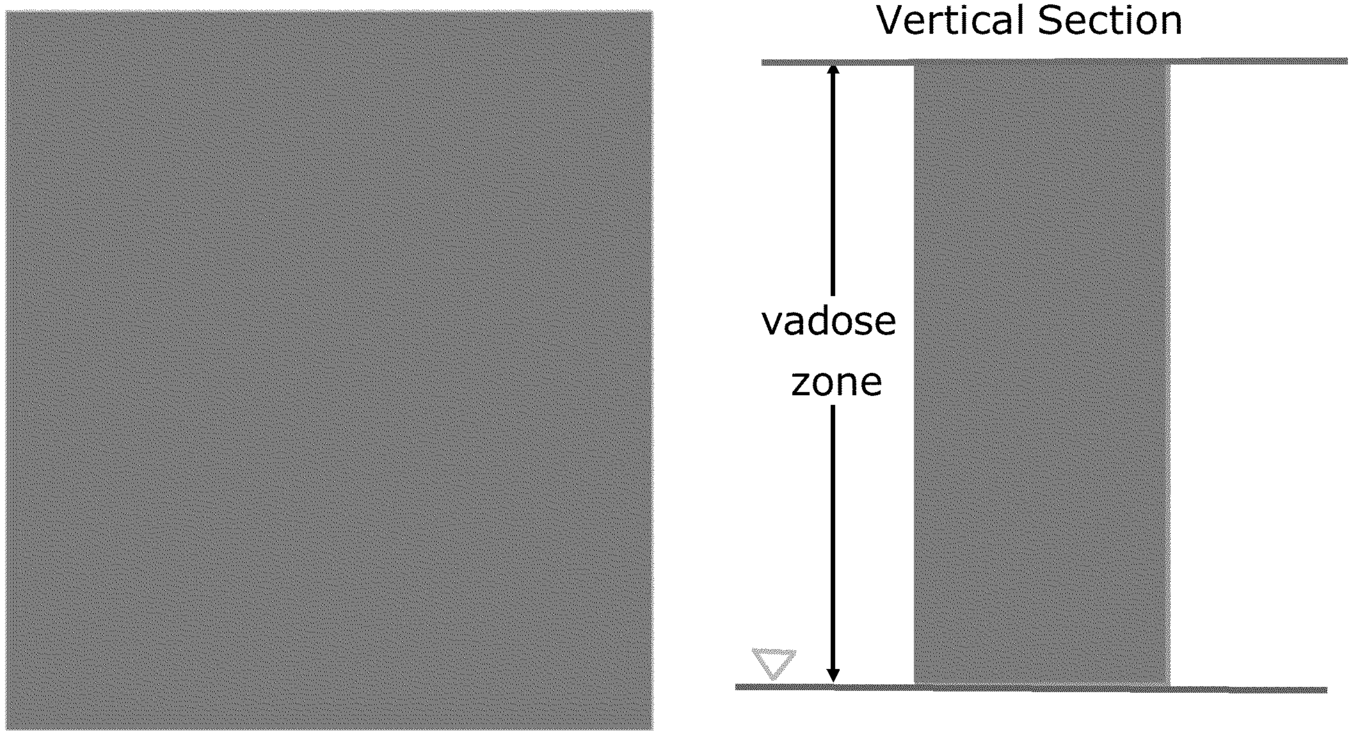


Areal Extent



Upper-Bound

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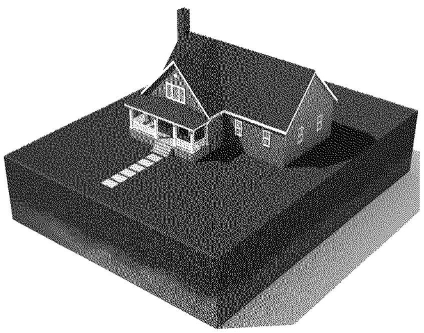

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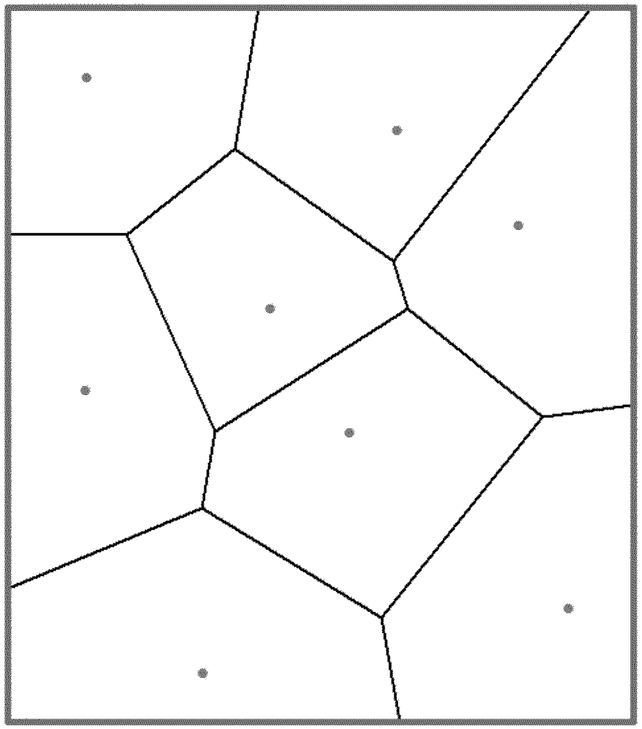
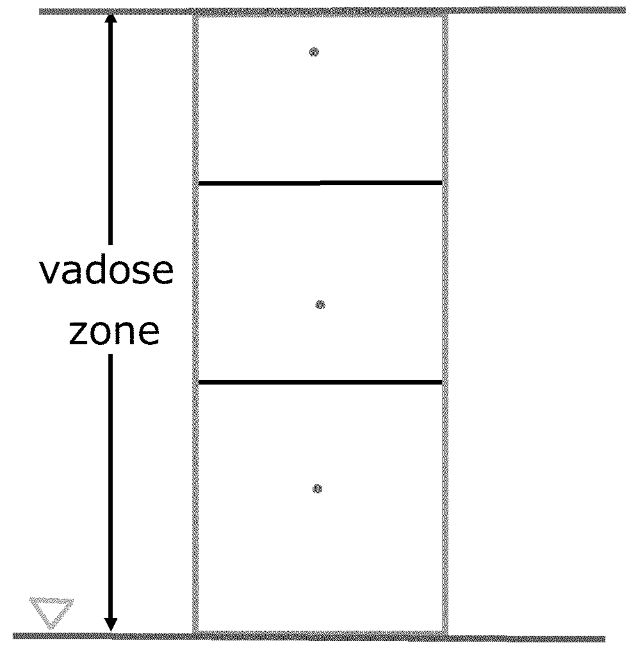


Vertical Section



Refined

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HOW DO WE ESTIMATE THE VOC MASS?

VOC mass can be calculated based on:

1. average of the soil concentrations
2. cumulative sum of mass increments

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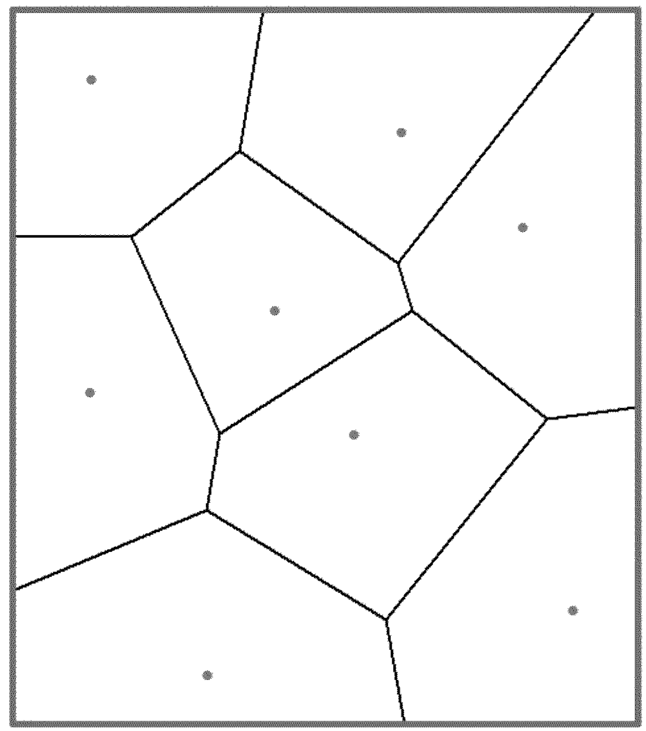

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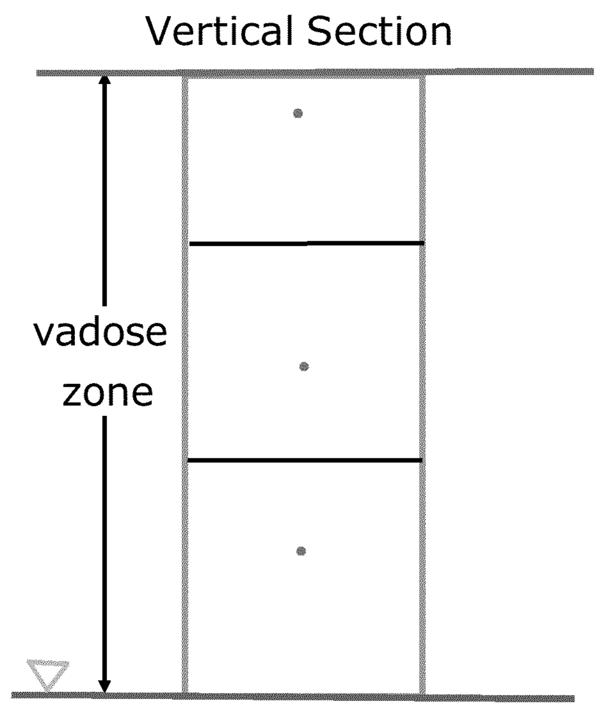

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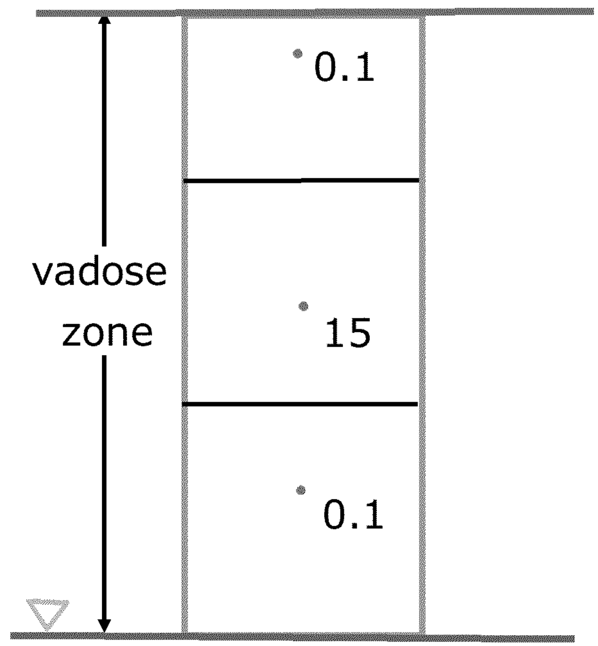
AVERAGING SOIL CONCENTRATIONS IN SOIL VOLUME UNDER THE BUILDING

VOC mass can be calculated using a volumetric average of soil concentrations (C_{avg}).

The volumetric average can be conservatively approximated by:

- Depth-weighted averaging at worst boring
- Area-weighted average using max concentration for each boring
- Combination of above

Vertical Section



$C_{avg} < 5.4$ mg/kg

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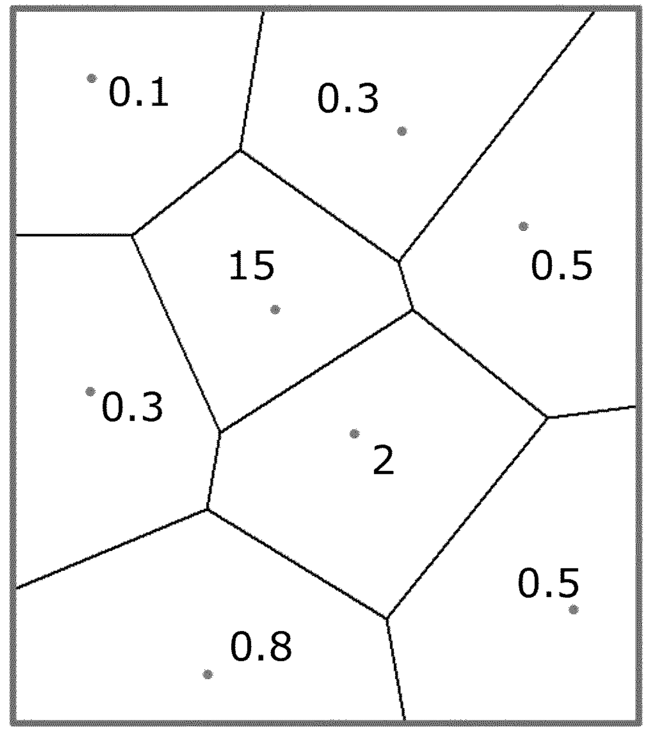

C_{avg} < 2.0 mg/kg

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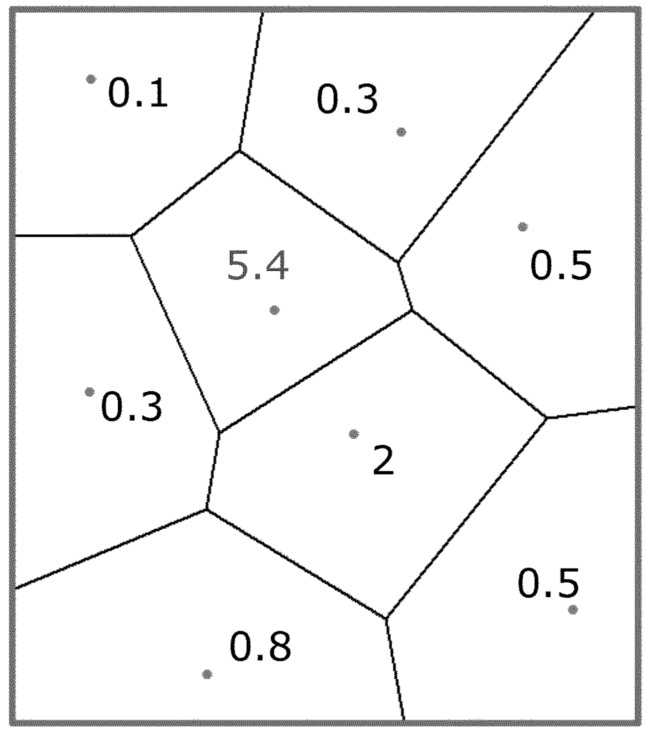
Combination



$C_{avg} < 1.1$ mg/kg

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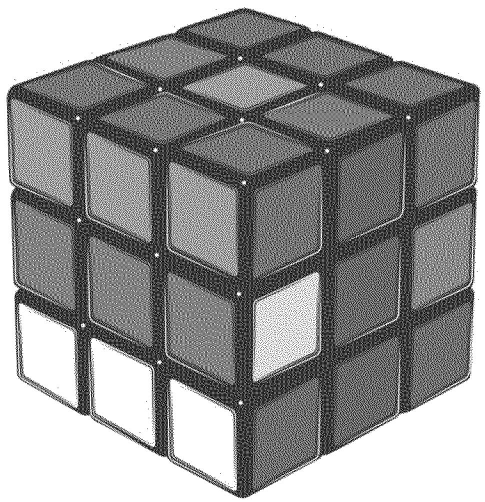
SUMMING INCREMENTS OF MASS UNDER THE BUILDING

$$IA = \frac{M}{V_{b,ED}}$$

$$M = \sum C_{soil} \times \rho_b \times V_{sample}$$

$$V_{b,ED} = Ach \times V_{occ} \times ED$$



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SOME PEOPLE DON'T LIKE THE "A" WORD

- Cannot average soil concentrations for VI
- Diluting the soil concentration
- Not accounting for preferential pathways

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HOW ABOUT EPA'S NEW GUIDANCE?

EPA	Counter-Points
Too much uncertainty associated with soil partitioning calculations	Mass balance method does not use soil partitioning calculations EPA uses soil partitioning to calculate RSLs and SSLs
Too much VOC loss during soil sampling	Encore sampler was designed to reduce VOC loss EPA allows use of VOC soil data for all other pathways

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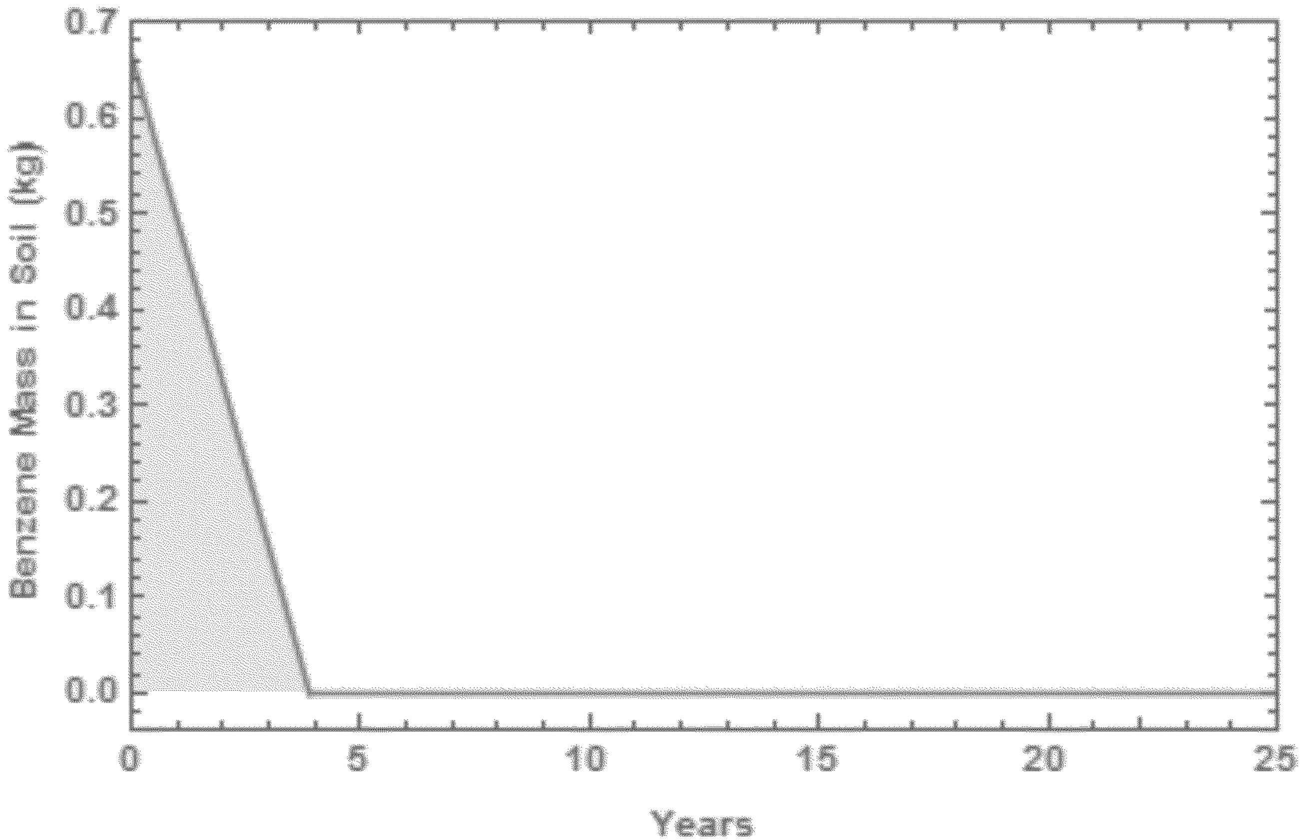
NOTHING EVER CHANGES?



Assumptions:

- Initial C_{soil} = 100 µg/kg
- ΔH = 10 meters
- VI is occurring

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KEY POINTS

1. There's usually not enough mass in the vadose zone to keep everything constant for 25+ years.
2. Putting the entire VOC mass in the vadose zone through the building is still very conservative.
3. Using the total VOC mass makes moot some of EPA's criticism on using soil data.
4. Let's hope things don't stay the same.

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THANK YOU

Abbreviations:

Ach – air exchange rate

C_{soil} – concentration of contaminant in the soil

ED – exposure duration

IA – indoor air

M – mass of contaminant

SG – soil gas

$V_{b,ED}$ - Volume of air that passes through building over exposure duration

V_{sample} – volume of vadose zone soil under the building represented by each sample

V_{soil} – total volume of vadose zone soil under the building

P_b – soil bulk density